Asian Review of Mechanical Engineering
ISSN: 2249 - 6289 Vol. 4 No. 2, 2015, pp. 26-29

A Review on an Opportunity to Reduce Exhaust Emission from Diesel Engine Using Exhaust Gas Recirculation

Hiren V. Mandalia
Mechanical Engineering Department,Government Polytechnic,Jamnagar, India
E-mail:hvmandalia@gmail.com

Abstract - **Internal combustion engines, plays an important role in the transportation sector and also in individual transport. Also it is a major source of manmade emissions. Presently there are many technologies are developed which are used to reduce the fuel consumption and exhaust emission from a diesel engine. In a CI engine fuel consumptions is reduced to a considerable amount, but the emission of NOx (Nitrogen Oxide) is a critical issue. This paper tries to present a review about the impact of EGR system on the exhaust emission of a CI engine. This is one of the methods which reduce the nitrogen oxide emissions of a diesel engine to a considerable level. In EGR – Exhaust Gas Recirculation method, a part of the exhaust gases is recirculated into the combustion chamber. Due to complete combustion of unburned fuel particles, there is a reduction in peak combustion temperature which in turn reduces the formation of NOX. By controlling the amount of available oxygen, which makes possibilities of reduction in the flame temperature in the combustion chamber, EGR system is effectively reduce the NOx emission from an engine.**
Keywords: **EGR system, NOx, HC, CO, Diesel engine, Emissions**

I. INTRODUCTION

All internal combustion engines use mixture of fuel and air in the cylinder. With the help of explosions, engine can generate the power. These cyclic explosions occur within the engine cylinder. Due to very high speed of the engine there is very short time for mixing of atomized fuel and air, which further leads to improper combustion. [1]. Stringent emission legislation are compelling the engine designer to reduce the exhaust emission because of which now a days, there are many technologies are used to reduce the emissions from diesel engine. By the use of developed technologies it is possible to manufacture an engine such that having low fuel consumption and very low COx and HC emissions even at high temperature. But at high temperature there is a considerable amount of NOx emission and it also emits the particulate matter (PM) with the smog. Therefore it is desirable to reduce the NOx emission from the engine. EGR (Exhaust Gas Recirculation) method is used to reduce the exhaust emission and to control effectively the NOx emission from diesel. It is proved that to recirculate the exhaust gases is an efficient method to reduce the NOx emission [3]. Also, mixing of exhaust gases with intake air, results in the reduction of flame temperature because of increase in specific heat of intake mixture. Thus combination of reduced flame temperature and lower oxygen quantity in the intake air reduces the rate of NOx formation considerable in the exhaust emissions from diesel engine [2, 3].

II.EXHAUST GAS RECIRCULATION

Diesel engine has high emission pollutants such as HC, CO, CO2 and NOx etc. to reduce this pollutant emission mainly NOx from diesel engine, EGR system can be used along with CI engine. [5]. In diesel engine, by increasing flame temperature emission of CO and HC can be reduced, but due to high temperature in the combustion chamber the NOx formation is increased. EGR system is used to reduce the NOx (Nitrogen Oxides) emission. Whenever combustion temperature exceeds about 25000 F NOx is formed in high concentrations [6]. In this Exhaust gas recirculation system some portion of an engine's exhaust gases are recirculated back into the engine cylinders. This further replaces some of the excess oxygen in the combustion chamber of the diesel engine.

As shown in figure 1 in EGR system exhaust gases are recirculated and mixed with intake air to the combustion. As exhaust gases displaced the fresh air it cause reduction in the oxygen concentration and also shows reduction in the A/F ratio. Re-circulated exhaust gases dislocate the fresh air entering into the combustion chamber with water vapor and carbon dioxide present in engine exhaust. As a consequence of this air dislocation, less amount of oxygen in the intake mixture is accessible for combustion. Reductions in oxygen content available for combustion reduce the adequate air–fuel ratio. Which further lowers the flame temperature during combustion process. Due to this reduction of ignition temperature, the NOx emission is reduced to a considerable level. By using EGR – exhaust gas recirculation method engine emits lower quantity of exhaust gases compared to that of non-EGR engines. It is because of part of the exhaust gas is re-circulated [4].

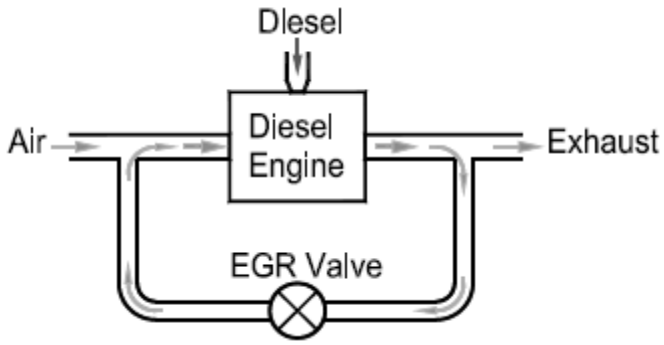

Fig .1 Exhaust Gas Recirculation

Jaffar Hussain et al [6] have been carried out an experiment to find out the effect of EGR on emissions and performance in a three cylinders, air cooled and constant speed direct injection diesel engine. They mainly target on different EGR rate in the engine. They considered carbon monoxide (CO), hydrocarbons (HC), exhaust gas temperature, NOx, and smoke opacity for measurement of the emission. They also calculated the performance parameter such as brake specific fuel consumption (BSFC) and thermal efficiency. They deduced that thermal efficiency is slightly decreased and BSFC is increased with EGR compared to that of without EGR. But NOx emission decreases significantly as exhaust gas temperature gets decreased with EGR. They noticed that 15% EGR rate is found to be efficient to reduce NOx emission substantially without wear off of engine performance in terms of thermal BSFC, efficiency, and emissions. Exhaust Gas Recirculation method can be applied to diesel engine without consecrate its fuel economy and efficiency and NOx reduction can thus be achieved. The increase in HC, CO, and PM emissions can be lowered by using exhaust after-treatment techniques, such as diesel oxidation catalysts (DOCs) and soot traps [7]. Its impact on reducing NOx emissions from bio diesel fuel combustion.

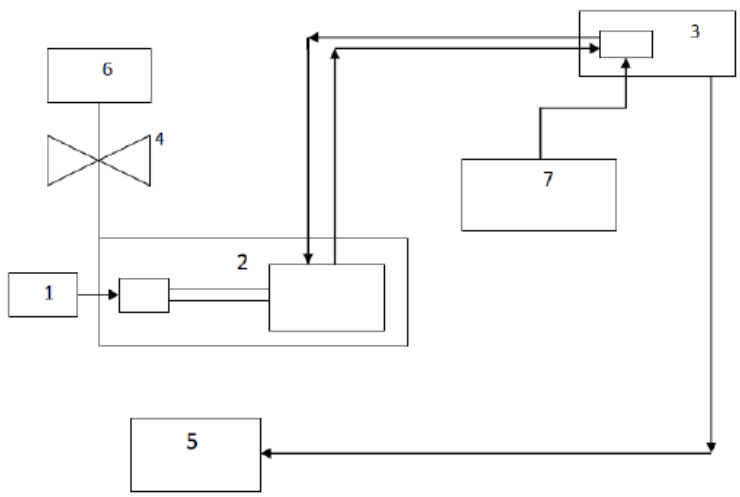

Fig..2 Line Diagram of EGR(Exhaust Gas Recirculation) Setup
1 Electrical loading, 2 Single cylinder 4-stroke diesel engine & Alternator, 3 Exhaust gas Recirculation System, 4 Control valve, 5 Gas Analyzer& Smoke meter, 6 Fuel Tank, 7 Air drum

III. RESULTS AND DISCUSSION

Reviews show that there is a considerable improvement in engine performance and emissions.

A. Oxides of Nitrogen (Nox)

Wagner et al. tried to accomplish lower emission of NOx and soot. For this he used highly diluted intake mixture. At very high EGR rate (around 44%), PM emission reduced sharply with a constant drop in NOx emission but this high EGR rate significantly affect the fuel consumption [10]. Das et al. used EGR in hydrogen – supplemented CI engine to reduce NOx emissions without any undesirable combustion consequence [9]. While applying EGR, with increase in the EGR rates, NOx emission is decreased. This is because of reduced oxygen concentration, which cause dilution of intake charge which further caused decreased flame temperature. There is a limitation for raising the EGR rate, as thermal efficiency will decrease in a high rate.[7]

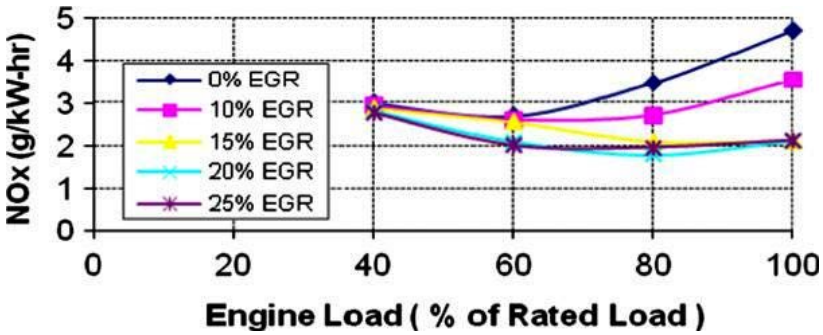

Fig.3 NOx for different EGR rates.

When temperature in the combustion chamber gets too high, Oxides of nitrogen (NOx) are formed. The oxygen and nitrogen in the combustion chamber can chemically combine to form nitrous oxides. Its further combination with hydrocarbons (HCs) in the presence of sunlight, produces an ugly haze in our skies known commonly as smog [11].

B. Hydrocarbons (HC)

Figure 4 shows variation of the HC with load for the different EGR rates for the CI engine. It is clear from the figure that the HC emission is increases with % EGR increases. But after 40% of load as the load is increases it becomes decreases. [8]

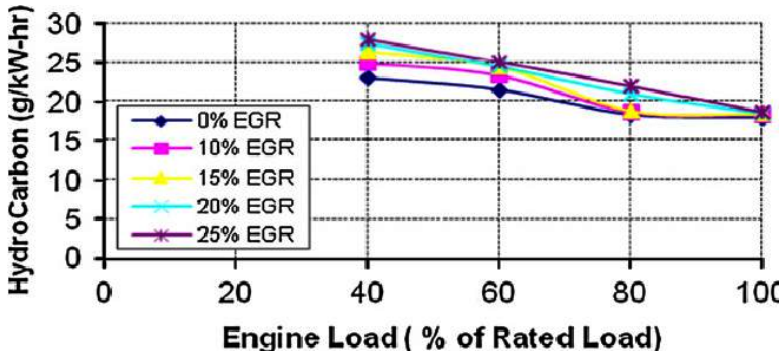

Fig. 4 HC for different EGR rates

C. Carbon monoxide

The existence of CO in the exhaust gas of an engine is a indication of the unburned chemical energy of the fuel. This is actually a loss of energy. Normally, the CO emission is affected by the type of fuel, combustion chamber design, atomization rate, engine speed and engine load. It is clear from the Figure 5 that the CO emission increases with the increase in load up to 60% of load and there after it shows decreases as the load increases [10].

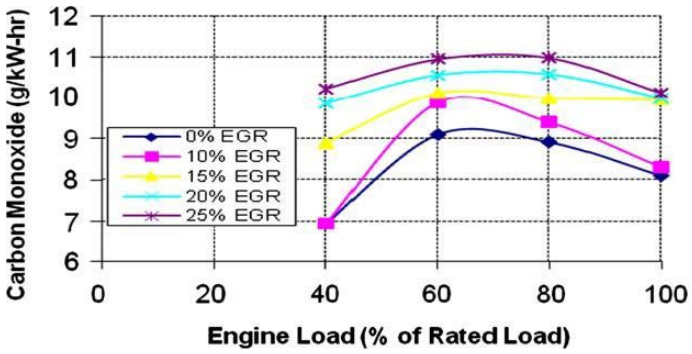

Fig. 5 CO for different EGR rates

IV.CONCLUSION

The CO emission is reduced throughout the engine operation with EGR gases in comparison to dual fuel mode of operation [6]. This review work concluded that, the EGR system reduces the NOx emission to a considerable level and the engines using EGR emit lower quantity of exhaust gases compared to non-EGR engines because part of the exhaust gas is re-circulated.

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